Physical and Mechanical Properties of OSB Made from Bamboo

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Abstract

A study was conducted to determine the potential of Betung bamboo (*Dendrocalamus asper* (Schult.f.) Backer ex Heyne) as one of non-conventional lignocelluloses resources for OSB production. Four types of OSB (strands without bark, strands with bark on the thick side, strands with bark on the wide side which placed on the top of face layer, the mixture of strands without bark and strands with bark on the wide side) and two type of adhesives (phenol formaldehyde and isocyanate) was produced in the form of three-layer and their properties were evaluated. The adhesives were applied at the level of 7%. Results showed that the physical properties of OSB made of bamboo strands using PF or IC can fulfill JIS A 5908 2003 standard. However, the OSB made of the mixture of strands without bark and strands with bark on the wide side using PF or IC adhesives cannot meet the standard in terms of their mechanical properties. In general, the OSB bonded with IC was better than that bonded with PF adhesive

Key words: Bamboo, OSB, Bark, Isocyanate, Phenol-Formaldehyde

Introduction

Oriented Strands Board (OSB) is a structural panels produced from thin strands of wood glued together using adhesive waterproof and heat pressured (Lowood 1997). OSB is a three-layer panel, made of strands which in the surface layers are placed parallel to the direction of panel production and in the core crosswise. OSB is similar in construction to plywood, and its bending strength, stiffness (modulus of elasticity) and dimensional stability are similar (Tsoumis 1991).

OSB is not only suitable made of commercial wood but can also be from low-value timber species or lesser-used species. Bamboo is one of lesser-used materials. Bamboo is lignocelluloses material that has been used widely in the Asian region as building material. Compared to the other fast growing species, bamboo only needs 3-5 years to mature. This short period make bamboo potential for mass and continuous production.

However, the utilization of bamboo as raw material for OSB production need to further explored due to the variability of bamboo culm. This is order to utilize bamboo efficiency.

The purpose of this study was to determine and compare the physical and mechanical properties of OSB produced from bamboo using different types of strands and adhesives. The produced OSB was expected to become an alternative substitution for plywood made of logs becoming in short supply.

Methods

Material Preparation. The betung bamboo (*Dendrocalamus asper* (Schult.f.) Backer ex Heyne) was prepared without nodes with 30 cm in length and then equally split into 4 parts. The split bamboos were then air-dried until ± 12% moisture content. Strands were then made with the size of 60-70 mm (L) x 16-20 mm (W) x 0.6 mm (T) in the forms of strands without bark, strands with bark on the thick side (cutting on the direction of the bamboo diameter), strands with the bark on the wide side as shown in Figure 1. All the produced strands were then oven dried at 60^{o}C to achieve 2-4% moisture content.

Adhesives used in this study were phenol formaldehyde (PF) with RSC 44,54% and isocyanate (IC) with RSC 99,14%.

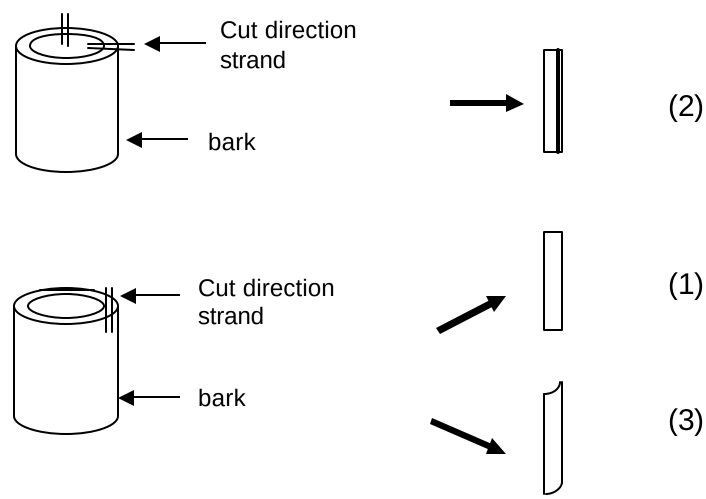

Fig.1. Cutting Direction for 3 Forms of Strands: (1) strand without bark; (2) strand with bark on the thick side (cutting on the direction of the bamboo diameter; (3) strand with the bark on wide side

OSB Production. Four types of OSB were separately made according to the types of bamboo strands, which were: (a) using strands without bark, b) using strands with bark on the thick side, c) using strands with bark on the wide side which placed on the top of face layer, d) using mixture strands without bark and strands with bark on the wide side. The two adhesives (PF and IC) were also separately applied to produce the four OSB types with the amount of 7% based on the weight of stands. Paraffin with the amount of 1% was also added in the production of OSB. Three-layer boards were made with the face and core layers perpendicular to each other. All the boards measured 30 cm X 30 cm X 0.9 cm were produced with the target density of 0.75 g/cm^3.

Physical and Mechanical Test. All produced OSB were conditioned for 14 days prior to testing. The quality of OSB was tested according to JIS 5908-2003. The physical and mechanical properties of OSB tested consisted of density, moisture content, thickness swelling and water absorption, internal bond, Modulus of Rupture (MOR), and modulus of elasticity (MOE).

Results and Discussion

Physical Properties

The physical properties of the produced OSB including density, moisture content, thickness swelling and water absorption are shown in Table 1. The density of all produced OSB fulfilled the JIS A 5908-2003. The density of produced OSB ranged between 0.70-0.85 g/cm^3. The density variations were caused by differences of strands bamboo densities used as they were made from different parts of bamboo. In general, OSB made of strands containing bark has a greater density than those without bark.

Table 1. Density (D), Moisture Content (MC), Thickness Swelling (TS), and Water Absorption (WA) of produced OSB

Sample	D (g/cm^3)	MC (%)	TS (%)		WA (%)	
			2 hour	24 hour	2 hour	24 hour
IC-a	0.70	7.83	0.44	2.14	7.61	29.06
IC-b	0.81	7.48	0.44	2.30	6.05	22.35
IC-c	0.75	6.75	0.06	1.32	4.74	19.73
IC-d	0.78	7.98	0.07	1.11	4.67	18.67
PF-a	0.70	6.13	1.22	5.47	10.67	37.12
PF-b	0.85	7.07	0.60	3.08	7.37	23.34
PF-c	0.73	6.58	1.29	8.61	8.65	32.00
PF-d	0.83	7.40	3.69	12.10	11.95	36.21
JIS	**0,40-0,90**	**5-13**	**-**	**< 25**	**-**	**-**

Table 1 also indicated that moisture content values of all produced OSB (6.13-7.98%) fulfilled the JIS A 5908-2003. The lowest moisture content was found on OSB made of strands with bark on the wide side which placed on the top of face layer. The silica content of bark made the OSB difficult in absorbing water. Results also showed that OSB produced with PF has lower moisture content than that produced with IC. This is probably because the viscosity of PF is lower than IC making it different in the adhesive distribution.

The determination of the OSB thickness swelling after 24-hour soaking resulted in the values of 1.11 - 12.10% (Table 1) which were much lower than JIS standard requiring the maximum value of 25%. OSB made of mixture strands without bark and strands with bark on the wide side bonded using PF had the highest thickness swelling. On the other hand, the same types of OSB with IC showed the lowest thickness swelling. These findings were in accordance with the previous result demonstrating that a better dimensional stability could be found on the boards bonded using IC (Marra, 1992).

As with the thickness swelling, water absorption of produced OSB with IC smaller than that produced with PF. This is due to the IC more water resistant than the PF so the bonding that occurs in strands can be damaged by water. OSB made with strands that contain bark (type b, c and d) have lesser water absorption than the OSB with strands without xthe bark. The existence of bark caused water very difficult to penetrate into OSB.

Mechanical Properties

The mechanical properties of the produced OSB including internal bond, modulus of elasticity and modulus of rupture are shown in Table 2. Internal bond is one of the parameters used to determine the strength of the particles bonds of OSB. The produced OSB in this study being not fulfilled JIS A 5908-2003 for internal bond was OSB made of the mixture of strands without bark and strands with bark on the wide side using PF. This is because the adhesive can not penetrate to the bark making the bonding strength weak. On the other hand, the same type OSB with IC met the standard. This result indicated the better quality of IC than PF in providing internal bonding for the produced OSB.

Table 2. Internal Bond (IB), Modulus of Elasticity (MOE) and Modulus of Rupture (MOR) of produced OSB

sample	IB (kgf/cm^2)	MOE ($10^4 kgf/cm^2$)				MOR (kgf/cm^2)			
		dry		Wet		dry		wet	
		L	W	L	W	L	W	L	W
IC-a	11.05	6.38	1.08	3.58	0.67	529	195	344	135
IC-b	7.36	8.72	1.48	4.81	0.66	532	210	362	111
IC-c	8.11	9.29	1.46	4.84	0.60	524	220	289	99
IC-d	4.54	5.57	1.13	2.55	0.33	450	136	151	56
PF-a	11.53	4.92	1.46	3.47	0.66	1101	244	552	219
PF-b	9.94	8.23	1.42	6.46	0.66	728	210	565	138
PF-c	11.53	7.04	1.45	5.07	0.76	797	209	476	192
PF-d	0.48	3.95	0.95	2.07	0.47	218	158	211	98
JIS	**>3,10**	**>4,08**	**>1,33**	**-**	**-**	**>245**	**>102**	**>122**	**>51**

Table 2 shows that MOE of OSB dry-tested on lengthwise ranged 3.95 - 9.29 x 104 kgf/cm^2, while that on widthwise ranged 0,95 - 1.48 x 104 kgf/cm^2. The produced OSB being not fulfilled JIS A 5908-2003 for MOE dry-tested on lengthwise was OSB made of the mixture of strands without bark and strands with bark on the wide side using PF.

The MOE dry-tested on widthwise was smaller than lengthwise because of the effect of the strand position on the tested sample. Compared to the lengthwise testing, the widthwise testing required less force because it was applied on the surface layer parallel to the grain.

The MOE observed at the wet testing on lengthwise ranged 2.07 - 6.46 x 10^4 kgf/cm^2, while that on widthwise ranged 0.33 - 0.76 x 10^4 kgf/cm^2. Similar to the result of dry testing, MOE of OSB on lengthwise was greater than that on widthwise but both of these values are not the requirement of JIS A 5908-2003. Table 2 also shows that the MOE of OSB on wet testing was smaller than that on dry testing. It is because of the influence of extreme treatment given prior testing. The highest MOE on wet testing was found on OSB made of strands with bark on the thick side using PF.

The result also showed that the MOR of OSB dry-tested on lengthwise being not fulfilled the standard was OSB made using PF with the mixture of strands without bark and strands with bark on the wide side. However, all the OSB dry-tested on widthwise fulfilled the standard. The highest MOR dry-tested on lengthwise was found on the OSB made using PF with strands without bark. Produced OSB bonded with PF was better than that with IC because PF can evenly distribute on the strands causing strong bonding properties. The MOR of OSB wet-tested either on lengthwise or widthwise ranged 151 - 565 kgf/cm^2 and 56 - 219 kgf/cm^2, respectively. These results indicated that all of the produced OSB fulfilled JIS A 5908-2003.

At wet testing on lengthwise, the highest MOR was found on OSB made of strands with bark on the thick side while the lowest MOR was found on OSB made of the mixture of strands without bark and strands with bark on the wide side. At the widthwise testing, the highest MOR was found on OSB made of strands without bark and the lowest MOR was shown by the OSB made of the mixture of strands without bark and strands with bark on the wide side bonded by either IC or PF. However, MOR of OSB bonded using PF was better than that using IC.

Conclusions

The physical properties of OSB made of bamboo strands using PF or IC can fulfill JIS A 5908 2003 standard. However, the OSB made of the mixture of strands without bark and strands with bark on the wide side using PF or IC adhesives cannot meet the standard in terms of their mechanical properties. The OSB made of strands with a thick bark on the side and that made of strands with bark on the wide side placed on the top of face layer has a quality similar to the OSB made of strands without bark. In general, the OSB bonded with IC was better than that bonded with PF adhesive.

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